DOCUMENT RESUME

ED 067 400 TM 001 795

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TITLE	The Interrupted Time Series as Quasi-Experiment: Three Tests of Significance. A Fortran Program for the CDC 3400 Computer.
INSTITUTION	Northwestern Univ., Evanston, Ill. Vogelback Computing Center.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C. Educational Media Branch.
REPORT NO	NUC-0049-TIMEX; Proj-C998
PUB DATE	Aug 65
CONTRACT	OEC-3-20-001
NOTE	41p.
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	*Computer Programs; *Data Analysis; *Mathematical Models; *Measurement Techniques; Programing Languages; Statistics; Tests; *Tests of Significance
IDENTIFIERS	Lev (J); Mood (S M); *TIMEX Program; Walker (H M)

ABSTRACT

Computational formulae for the following three tests of significance, useful in the interrupted time series design, are given: (1) a "t" test (Mood, 1950) for the significance of the first post-change observation from a value predicted by a linear fit of the pre-change observations; (2) an "F" test (Walker and Lev, 1953) of the hypothesis that one regression line fits both pre and post-change groups; and (3) a "t" test of the difference between pre-change and post-change regression estimates of the occasion value lying midway between the last pre-change point and the first post-change point (Mood, 1950; Walker and Lev, 1953). The computer program TIMEX is designed to perform the following statistical tests on data of the interrupted time series form: Mood test, Walker-Lev covariance tests, and "double extrapolation." In addition to "t" or "F" values of each statistical test of significance, other information may also be obtained; this information is indicated. Program limitations, card preparation, and order of cards are presented. The computer program is provided in a printout, as is the test data for the program. The test data plot is also reproduced. Appendix I is Interpretation of Data Plot with Missing Regression Points, and Appendix II is Program Modifications for Fortran II and IV. (Author/DB)

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THE INTERRUPTED TIME SERIES AS QUASI-EXPERIMENT:

THREE TESTS OF SIGNIFICANCE*

A Fortran Program for the CDC 3400 Computer

Joyce Sween and Donald T. Campbell

August, 1965

Distributed by the Vogelback Computing Center

Northwestern University as NUC 0049 TIMEX

TM 001 795

*Supported by Project C998, Contract 3-20-001, Educational Media Branch Office of Education, U.S. Department of Health, Education, and Welfare, under provisions of Title VII of the National Defense Education Act.

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The Interrupted Time Series as Quasi-Experiment:

Three Tests of Significance

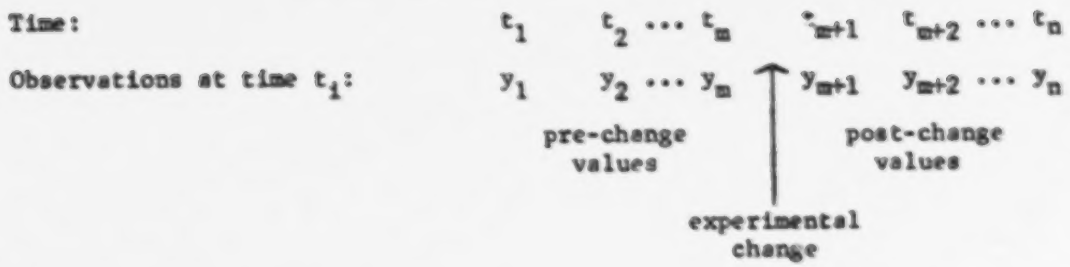
A Fortran Program for the CDC 3400 Computer

Joyce Sween and Donald D. Campbell

Studies are classified as quasi-experimental where random assignment to treatments is not possible. Campbell and Stanley (1963) have assembled a considerable number of such designs, of which the interrupted time series is one. A discussion of the time series design as a quasi-experimental method and the problems of statistical tests and of internal validity for this design are presented in Campbell and Stanley (1963) and Campbell (1963).

The essence of the interrupted time series experiment is the presence of a periodic measurement process in some individual or group and the introduction of an experimental change into this time series of measurements. The kind of time series that is considered here is a finite sequence of observations which are real-valued measurements obtained at n successive equally spaced points in time. The experimental change or treatment is assumed to occur between two consecutive measurements. Measurements obtained prior to the treatment are referred to as pre-change values; measurements obtained after the treatment are post-change values. It can be diagrammed as follows:

Interrupted Time Series Design


Time: t_1 t_2 ... t_m t_{m+1} t_{m+2} ... t_n
Observations at time t_i: y_1 y_2 ... y_m y_{m+1} y_{m+2} ... y_n
pre-change values
post-change values
experimental change

Three Statistical Tests of Significance

If the treatment has produced an effect, a discontinuity of measurement is recorded in the time series. It is desirable, of course, to have available some statistical test of significance that would distinguish such a treatment effect from purely random fluctuation. A recent Monte Carlo investigation (Sween and Campbell, 1965) indicated that the following three statistical tests were useful in the interrupted time series design:

(a) A t test (Mood, 1950, pp. 297-298) for the significance of the first post-change observation from a value predicted by a linear fit of the pre-change observations.

(b) An F test (Walker and Lev, 1953, pp. 390-395) of the hypothesis that one regression line fits both pre- and post-change groups.

(c) A t test of the difference between pre-change and post-change regression estimates of the occasion value lying midway between the last pre-change point and the first post-change point (Mood, 1950, pp. 350-358; Walker and Lev, 1953, pp. 390-400).

Computational formulae for these three tests are described in detail on the following pages.

Mood Test. Mood (1950, pp. 297-298) provides a t test for the significance of the difference between the first post-change observation and a

predicted value based upon a linear fit of the pre-change observations. The formula for $\underline{t}$ is given below:

$$t = \frac{(Y_0 - \hat{Y}_0)/\sigma_u}{\sqrt{m\hat{\sigma}^2/(m-2)\sigma^2}}$$

The computer program first obtains the pre-change regression estimates.

$$\hat{\beta} = \frac{\sum_{i=1}^{m} t_i Y_i - \left[\left(\sum_{i=1}^{m} t_i\right)\left(\sum_{i=1}^{m} Y_i\right)/m\right]}{\sum_{i=1}^{m} t_i^2 - \left(\sum_{i=1}^{m} t_i\right)^2/m}$$

$$\hat{\alpha} = \bar{Y} - \hat{\beta}\bar{t}$$

where m = number pre-change observations

$i = 1, 2, \ldots m$

$$\bar{y} = \sum_{i=1}^{m} Y_i/m$$

$$\bar{t} = \sum_{i=1}^{m} t_i/m$$

An estimate, $\hat{Y}_0$, of the first post-change value is obtained.

$$\hat{Y}_0 = \hat{\alpha} + \hat{\beta}t_0$$

The difference between the estimated value and the obtained first post-change value, $Y_0 - \hat{Y}_0$, is used in the $\underline{t}$ test. However, $\sigma_u = \sqrt{\sigma^2\left[\frac{m+1}{m} + \frac{(t_0-\bar{t})^2}{\sum_{i=1}^{m}(t_i-\bar{t})^2}\right]}$ and an estimate, $\hat{\sigma}^2$, of σ^2 is given by $\hat{\sigma}^2 = \frac{1}{m}\sum_{i=1}^{m}(Y_i - \hat{\alpha} - \hat{\beta}t_i)^2$. Thus, the computation formula for the $\underline{t}$ test of the difference between the obtained and predicted points is given by

$$t = \frac{Y_0 - \hat{Y}_0}{\sqrt{\left[\frac{m+1}{m} + \frac{(t_0-\bar{t})^2}{\sum(t_i-\bar{t})^2}\right]\left[\sum_{i=1}^{m}\frac{(Y_i - \hat{\alpha} - \hat{\beta}t_i)^2}{m-2}\right]}}$$

The denominator is the standard error of the difference from $\underline{t}$. The $\underline{df}$ for $\underline{t}$ is (m-2).

Walker-Lev Tests.--Walker and Lev (1953, pp. 390-395) provided the following tests of significance. These tests are useful in determining whether differences exist between the regression equations for pre- and post change groups.

Test One.

This is a test of the hypothesis of common slope. The F ratio is given by $F = \frac{S_1}{S_2} \cdot \frac{(N-4)}{1}$

where S_1 = sum of squares of the common within groups regression estimates from the separate group regression estimates

$$\sum_{i=1}^{2} \sum_{j=1}^{N_i} \left[(\hat{\alpha}_i + \hat{\beta}_i t_{ij}) - (\hat{\alpha}_{\omega i} + \hat{\beta}_\omega t_{ij}) \right]^2$$

S_2 = sum of squares of the obtained occasion values from the separate group regression estimates

$$\sum_{i=1}^{2} \sum_{j=1}^{N_i} \left[(Y_{ij} - (\hat{\alpha}_i + \hat{\beta}_i t_{ij}) \right]^2$$

N = total number of occasions in time series
i=1,2 [1=prechange group; 2=postchange group]
j = 1, 2. . . N_1

Formulas for the common within groups slope and intercept are

$$\hat{\beta}_\omega = \frac{CTY_\omega}{CTT_\omega}$$

$$\hat{\alpha}_{\omega i} = \bar{Y}_i - \hat{\beta}_\omega \bar{t}_i$$

Formulas for the separate group slopes and intercepts are

$$\hat{\beta}_i = \sum_{j=1}^{N_i} t_{ij} Y_{ij} - \left(\sum_{j=1}^{N_i} t_{ij} \right) \left(\sum_{j=1}^{N_i} Y_{ij} \right) \Big/ N_i$$

$$\hat{\alpha}_i = \bar{Y}_i - \hat{\beta}_i \bar{t}_i$$

The computational formulae for the numerator and denominator sum of squares for the F ratio are

$$S_1 = \sum_{i=1}^{2} \frac{CTY_i}{CTT_i} - \frac{C^2 TY_\omega}{CTT_\omega}$$

$$S_2 = CYY_\omega - \sum_{i=1}^{2} \frac{C^2 TY_i}{CTT_i}$$

where

$$CTT_i = \sum_{j=1}^{N_i} t_{ij}^2 - \left[\left(\sum_{j=1}^{N_i} t_{ij}\right)^2 / N_i\right]$$

$$CTY_i = \sum_{j=1}^{N_i} t_{ij} Y_{ij} - \left[\sum_{j=1}^{N_i} t_{ij} Y_{ij} / N_i\right]$$

$$CYY_i = \sum_{j=1}^{N_i} Y_{ij}^2 - \left[\left(\sum_{j=1}^{N_i} Y_{ij}\right)^2 / N_i\right]$$

$$CTT_\omega = \sum_{i=1}^{2} CTT_i$$

$$CTY_\omega = \sum_{i=1}^{2} CTY_i$$

$$CYY_\omega = \sum_{i=1}^{2} CYY_i$$

The resulting F ratio is evaluated with 1 and N-4 degrees of freedom.

Test Two:

This is a test of the hypothesis that the slopes of the pre- and post-change groups are equal to zero when it has been established that $\hat{\beta}_i = \hat{\beta}_\omega$ (that is, F of Test One is not significant). The variance ratio is given by

$$F = \frac{C^2 TY_\omega}{CTT_\omega \cdot CYY_\omega - C^2 TY_\omega} \cdot \frac{(N-4)}{1}$$

and is evaluated with 1 and N-4 degrees of freedom.

Test Three:

This is a test of the hypothesis that a single regression line fits both the pre- and post-change groups. The F ratio is given by $F = \frac{S_b}{S_\omega} \cdot \frac{(N-3)}{1}$

where S_b = sum of squares of common within groups regression estimates from the total series regression estimates

$$\sum_{i=1}^{2} \sum_{j=1}^{N_i} \left[\left(\hat{\alpha}_{\omega_i} + \hat{\beta}_\omega t_{ij}\right) - \left(\hat{\alpha}_T + \hat{\beta}_T t_{ij}\right)\right]^2$$

S_w = sum of squares of obtained occasion values from the common within groups regression estimates

$$\sum_{i=1}^{2} \sum_{j=1}^{N_i} \left[Y_{ij} - \left(\hat{\alpha}_{\omega_i} + \hat{\beta}_\omega t_{ij}\right)\right]^2$$

Formulas for the total series slope and intercept are

$$\hat{\beta}_T = \frac{CTY_T}{CTT_T}$$

$$\hat{\alpha}_T = \bar{y} - \hat{\beta}_T \bar{t}$$

The computational formulae for the numerator and denominator sum of squares for the F ratio are

$$S_b = CYY_B + \frac{C^2 TY_W}{CTT_W} - \frac{C^2 TY_T}{CTT_T}$$

$$S_W = S_1 + S_2$$

where

$$CTY_T = \sum_{i=1}^{2} \sum_{j=1}^{N_i} t_{ij} Y_{ij} - \left[\left(\sum_{i=1}^{2} \sum_{j=1}^{N_i} t_{ij} \right) \left(\sum_{i=1}^{2} \sum_{j=1}^{N_i} Y_{ij} \right) \Big/ N_i \right]$$

$$CYY_T = \sum_{i=1}^{2} \sum_{j=1}^{N_i} Y_{ij}^2 - \left[\left(\sum_{i=1}^{2} \sum_{j=1}^{N_i} Y_{ij} \right)^2 / N \right]$$

$$CTT_T = \sum_{i=1}^{2} \sum_{j=1}^{N_i} t_{ij}^2 - \left[\left(\sum_{i=1}^{2} \sum_{j=1}^{N_i} t_{ij} \right)^2 / N \right]$$

$$CYY_B = CYY_T - CYY_W$$

The resulting F ratio is evaluated with 1 and N-3 degrees of freedom.

"Double Extrapolation" Technique.--This test (Mood, 1950, pp. 350-358; Walker and Lev, 1953, pp. 399-400) is concerned with the significance of the difference between two separate regression estimates of the y-value for time t_o which lies midway between the last pre-change point and the first post-change point. Reference to the interrupted Time Series Design diagrammed on page 2 will indicate that this point lies midway between t_m and t_{m+1}. Assuming that the points are equally spaced in time, t_o is equal to $t_{m+.5}$.

The first regression estimate for y_o is obtained from the pre-change values; the second regression estimate for y_o, from the post-change values.

The formulas for the two regression estimates are

$$\hat{\beta}_i = \frac{\sum_{j=1}^{N_i} t_{ij} Y_{ij} - \left[\left(\sum_{j=1}^{N_i} t_{ij}\right)\left(\sum_{j=1}^{N_i} Y_{ij}\right)/N_i\right]}{\sum_{j=1}^{N_i} t_{ij}^2 - \left(\sum_{j=1}^{N_i} t_{ij}\right)^2/N_i}$$

$$\hat{\alpha}_i = \bar{Y}_{ij} - \hat{\beta}\bar{t}_{ij}$$

where $i = 1, 2$ [1 = prechange group; 2 = post-change group]
N_i = number occasions in group i
$j = 1, 2, \ldots N_i$

Thus, the two estimates for y_o are given by $\hat{Y}_{o_i} = \hat{\alpha}_i + \hat{\beta}_i t_o$. The difference between these two estimates can be evaluated by the t ratio $t = \frac{|\hat{Y}_{o_1} - \hat{Y}_{o_2}|}{S_D}$ and its significance determined by reference to a t table with $N_1 + N_2 - 4$ degrees of freedom. The standard error of the difference for t depends upon the variability of the pre- and post-change values, N_1 and N_2, the relation between t and y, and the distance of t_o from $\bar{t}_1$ and $\bar{t}_2$. The formula for the standard error is given in Walker and Lev as

$$S_D = \sqrt{\frac{\left[\sum_{i=1}^{2}\left(CYY_i - \frac{C^2TY_i}{CTT_i}\right)\right]\left[\frac{N_1+N_2}{N_1N_2} \quad \sum_{i=1}^{2}\frac{(t_o - t_i)^2}{CTT_i}\right]}{N_1+N_2-4}}$$

where

$$CYY_i = \sum_{j=1}^{N_i} Y_{ij}^2 - \left(\sum_{j=1}^{N_i} Y_{ij}\right)^2/N_i$$

$$CTT_i = \sum_{j=1}^{N_i} t_{ij}^2 - \left(\sum_{j=1}^{N_i} t_{ij}\right)^2/N_i$$

$$CTY_i = \sum_{j=1}^{N_i} t_{ij} Y_{ij} - \left(\sum_{j=1}^{N_i} t_{ij} \sum_{j=1}^{N_i} Y_{ij}\right)/N_i$$

Considerations for Using Tests of Significance

The following points should be considered in utilization of these three tests of significance.

(1) The three tests are linear tests of intercept and/or slope. In instances of significance, curvilinear relationships must be ruled out as rival hypotheses explaining the post-change effect. Thus, a plot of the time series should be examined to determine by visual inspection if other than a linear fit seems plausible. (The present FORTRAN program provides a data plot of the time series).

(2) Both pre-treatment and post-treatment measurements are necessary for a time series analysis. In general, there should be sufficient pre-change and post-change data available to establish a trend. For the Mood test only one post-change point is required, but additional post-change data would be helpful in ruling out rival hypotheses.

(3) The three tests of significance are not equally applicable to all time series analyses, as the following examples should illustrate. The time series of A1 and A2 of Figure 1 are instances of sustained post-change effect involving a change in intercept whereas B1 and B2 show an initial rise and

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Insert Figure 1 about here

---

subsequent return to pre-change conditions. If theoretical expectations are appropriate to using a series of points in the post-change period (as they would be in A1 and A2) the Walker-Lev Test 3 and "double extrapolation" technique would be most suitable. These two statistics would not be used in instances of theoretical expectations similar to B1 and B2 where only the Mood test of the significance of the first post-change observation from a trend extrapolated from the pre-change observations would be appropriate.

A time series analysis appears to be most applicable in the instances cited above. In C1 and C2 where the post-treatment effect involves a change

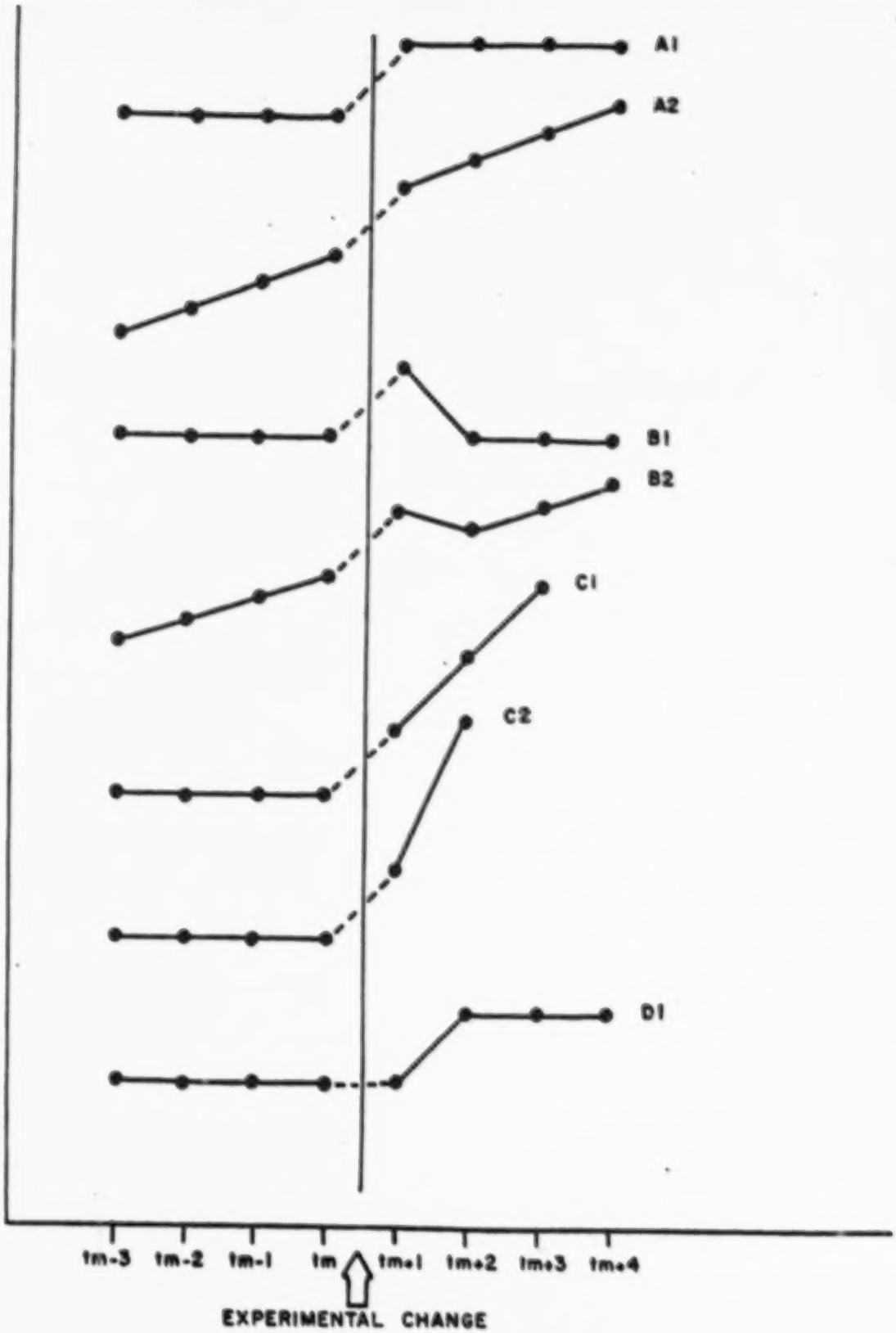


Fig. 1. Some possible outcome patterns for the interrupted time series experiment.

in slope and, generally, of intercept, the possibility of a curvilinear relationship is more difficult to rule out. Although all three statistical tests may be appropriate here (depending upon the theoretical expectations of the investigator), they may yield conflicting results. For example, the "double extrapolation" technique could be used to indicate if the pre- and post-regression lines coincide at time, t_0, midway between the last pre-change and first post-change point. However, in instances like C2 both regression lines coincide at time t_o even though their slopes and intercepts are dissimilar.

In instances of delayed effect, such as D1, ambiguity is introduced into the interpretation of significance. For as the time interval between the treatment and its effect increases, the plausibility of rival hypotheses also increases. In using the tests of significance, it is essential that the investigator specify in advance the time relationship between the introduction of the treatment and the manifestation of its effect. If a delayed effect is hypothesized, all points prior to the effect should be regarded as pre-change points. (The Occasion Card used as input to the program must also be punched accordingly.)

(4) Statistical models on which these tests of significance are based make the minimal assumptions that the errors have equal variances and expected values of zero. In addition, the errors are assumed to be uncorrelated. However, the observed values may not always exhibit independent errors. It may frequently occur that measurements made closely together in time are more strongly related. When such dependence between the measurements exists, the assumption of independence is not met. Although this circumstance does not prevent utilization of the tests of significance with interrupted time

series data, the Monte Carlo study (Sween and Campbell, 1965) indicated that if correlated error exists, use of these tests with the tabled critical values will produce significant results by chance alone more than one percent (or five percent) of the time. The degree to which the one percent and five percent levels of significance were exceeded depended upon the amount of autocorrelation between points. This was found to hold particularly for the Walker-Lev Tests and the "double extrapolation" technique. In lieu of these findings, the corrections described below are advised in instances where the assumption of independent error is not justified.

Use of Tests When Assumption of Uncorrelated Error is not Met

On the bases of the Monte Carlo study, it is suggested that when a significant autocorrelation exists, the critical values of F (Walker-Lev tests) and of t ("double extrapolation" technique and Mood test) be increased to approximate more closely the 1% and 5% levels of significance. Only a slight correction, if any, is needed for the Mood test. Reference to the graphs in Figures 2-7 should facilitate the approximations. The new critical values can be determined by interpolating on the abscissa using the first autocorrelation coefficient (i.e., for a lag of one step) and then interpolating for the total N (or pre-change N (Mood Test)) of the series on the face of the graph. The new critical value is read on the ordinate.

Insert Figures 2-7 about here

As the graphs indicate, when observations are not correlated the critical values yielding significant results one and five percent of the time by

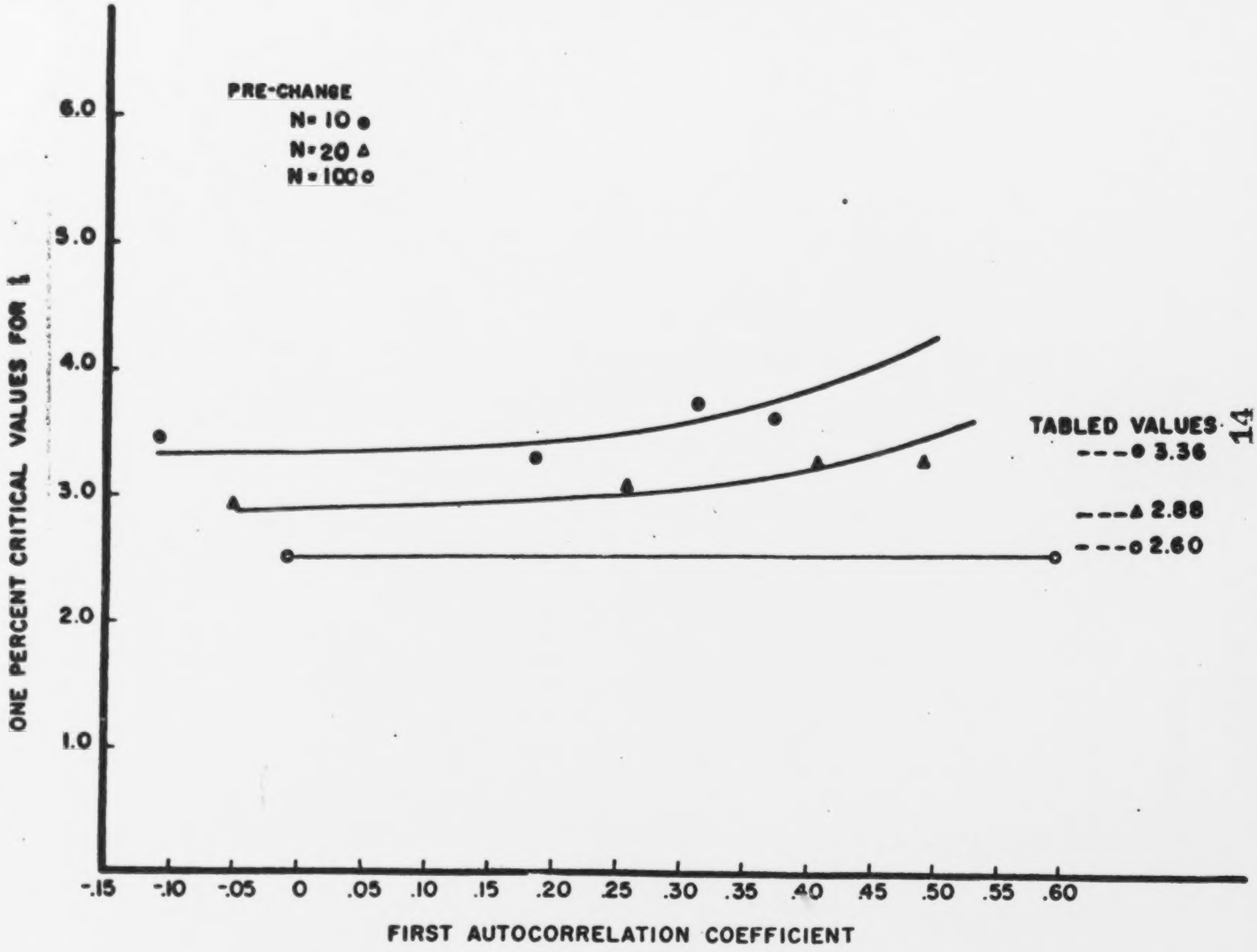


Fig. 2. Mood test: Obtained one percent critical values of t as a function of the first autocorrelation coefficient.

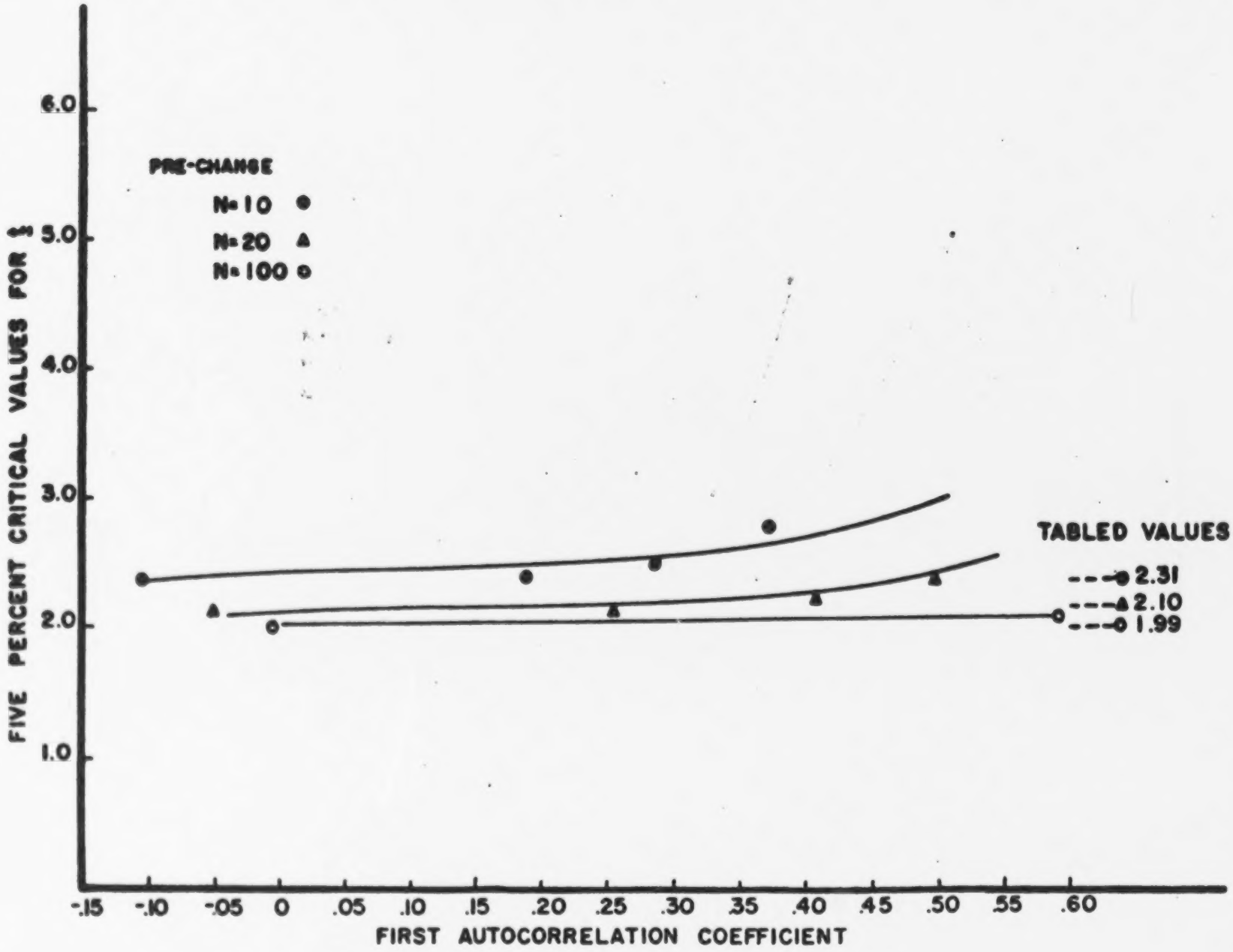


Fig. 3. Mood test: Obtained five percent critical values of t as a function of the first autocorrelation coefficient.

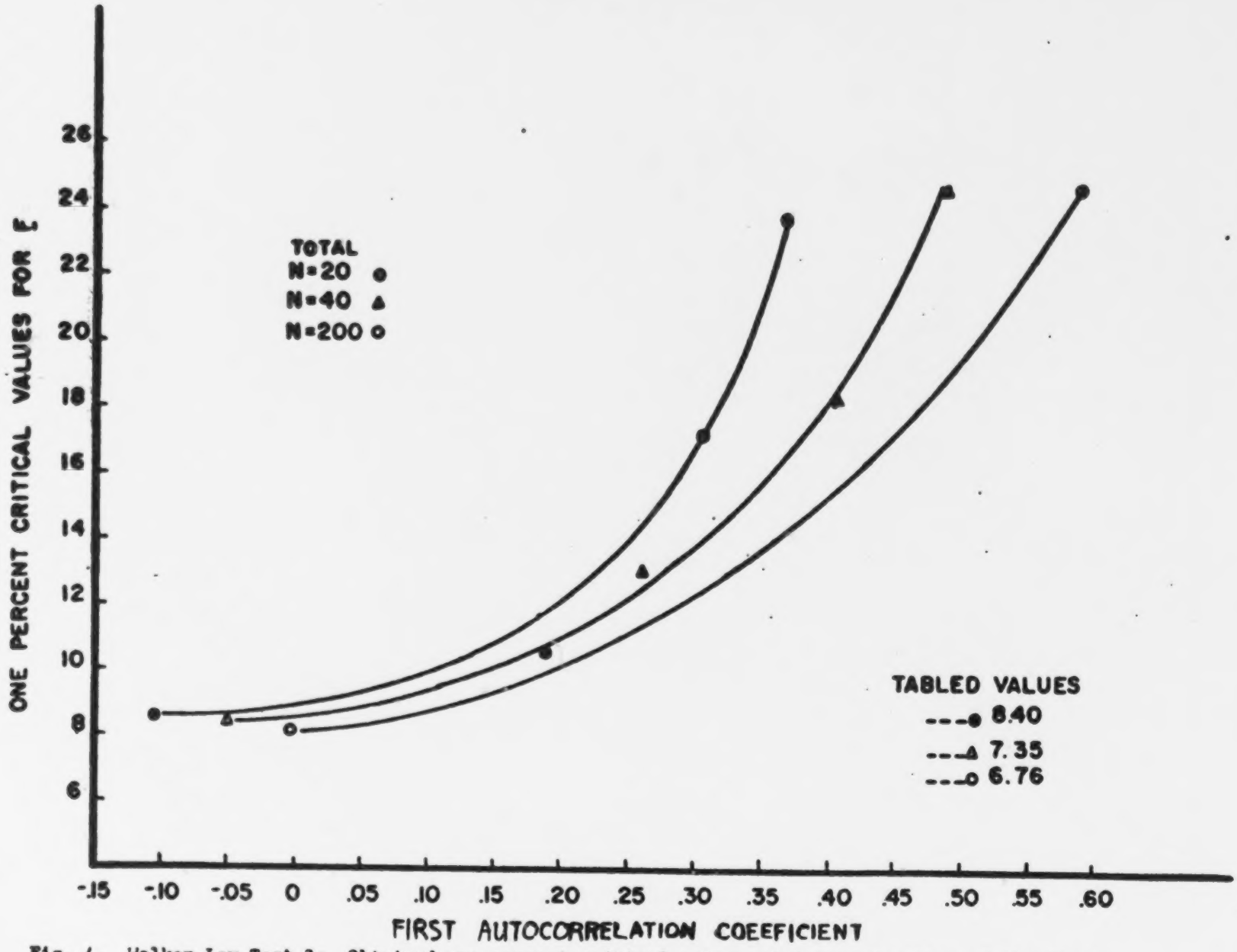


Fig. 4. Walker-Lev Test 3: Obtained one percent critical values of F as a function of the first autocorrelation coefficient.

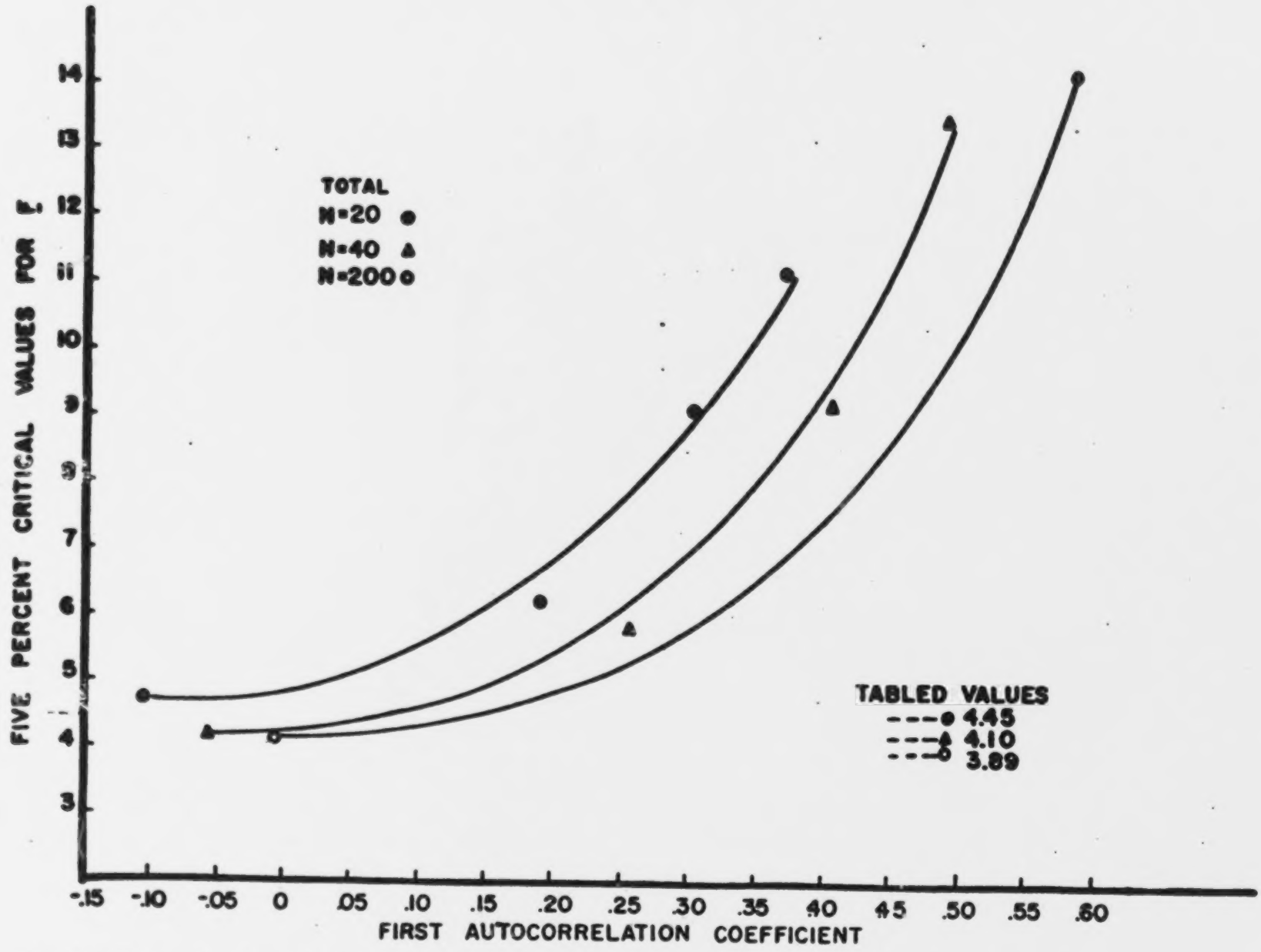


Fig. 5. Walker-Lev Test 3: Obtained five percent critical values of F as a function of the first autocorrelation coefficient.

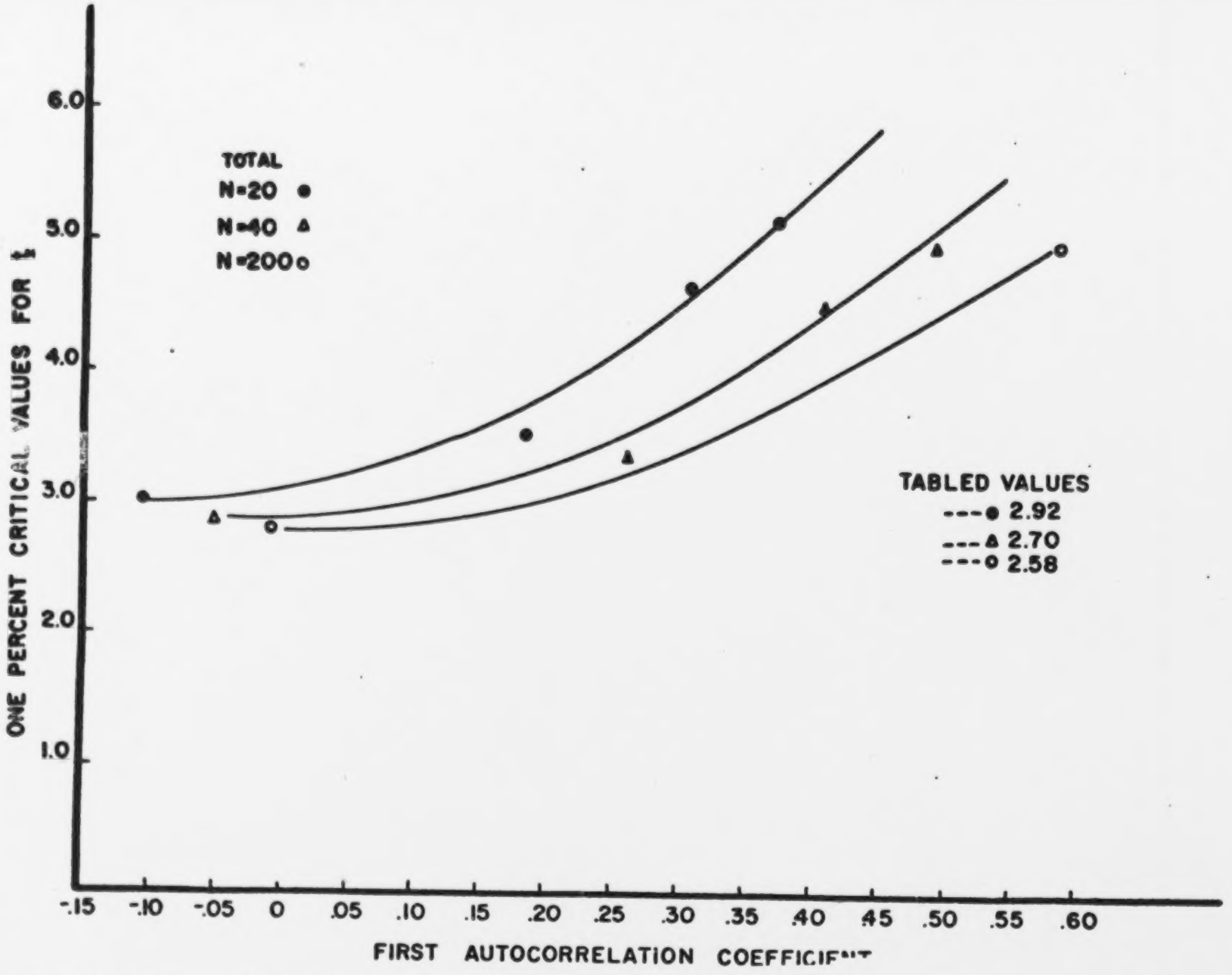


Fig. 6. Double Extrapolation Technique: Obtained one percent critical values of t as a function of the first autocorrelation coefficient.

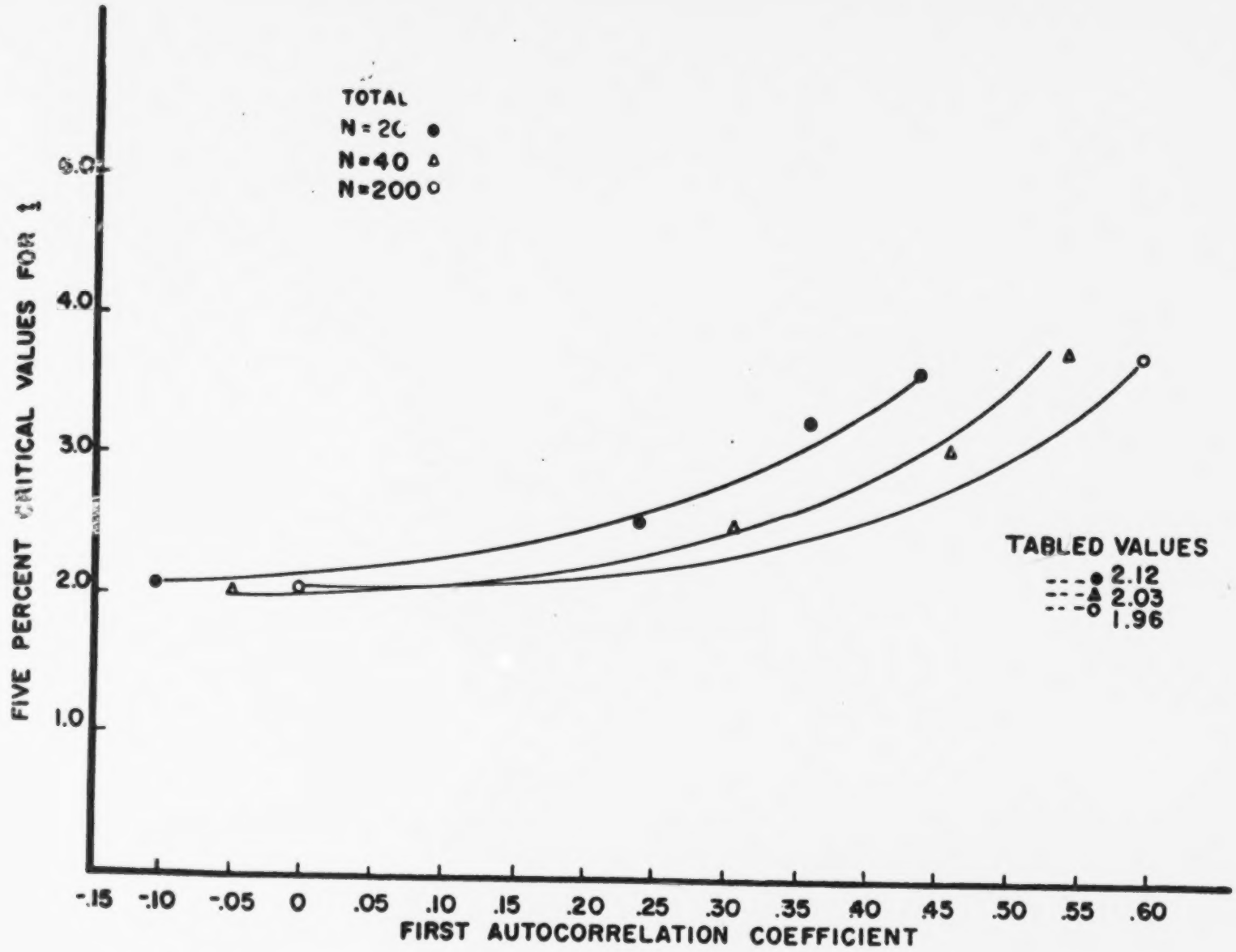


Fig. 7. Double Extrapolation Technique: Obtained five percent critical values of $\underline{t}$ as a function of the first autocorrelation coefficient.

chance alone are, in general, similar to the tabled critical values for all three tests of significance. However, when a significant proximal autocorrelation exists between points, that is, when a given observation is dependent upon preceding observations, the critical values yielding significant results one and five percent of the time are similar to the tabled critical values for the Mood test only. For both the Walker-Lev tests and the "double extrapolation" test, the critical values rise with increasing autocorrelation.

Auto-correlation Coefficients

The scientist usually does not have knowledge of the degree of sequential dependency which exists in a given time series. The first serial correlation coefficient (of lag one) is used to determine whether the observations of a given time series can be regarded as consisting of independent error only (measures not correlated). The serial correlation coefficient tests the hypothesis that the order of dependence in the time series is zero against the alternative that it is one. Serial correlation coefficients of lags higher than one could also be considered. (If the serial correlation is that of a variable with itself, it may be referred to as an auto-correlation coefficient.)

A serial correlation coefficient of lag one, r_1, is obtained by pairing observations one time unit apart; that is, the first observation is paired with the second, the second with the third, etc., throughout the entire time series until the last observation is reached. The product-moment correlation is computed using the resulting pairs of observations. In a similar manner, the second serial correlation coefficient, r_2, is obtained by pairing successive observations two time units apart and r_m is obtained

by pairing observations a units apart. The basic formula for r_a is given below:

$$r_a = \frac{n\sum_{i=1}^{n} Y_i Y_{i+a} - \left(\sum_{i=1}^{n} Y_i\right)\left(\sum_{i=1}^{n} Y_{i+a}\right)}{\sqrt{\left[n\sum_{i=1}^{n} Y_i^2 - \left(\sum_{i=1}^{n} Y_i\right)^2\right]\left[n\sum_{i=1}^{n} Y_{i+a}^2 - \left(\sum_{i=1}^{n} Y_{i+a}\right)^2\right]}}$$

where N = total number of occasions in the time series

n = N-a

i = 1,2,...n

When the slope of the regression line is <u>not</u> equal to zero, the presence of trend will increase the values of the autocorrelation coefficients. Thus, in this instance, interest would be in the autocorrelation of departures from the line of best fit for the total series. In the instance of a true effect (slopes and/or intercepts of pre- and post-change groups differ), the autocorrelation of the differences from the separate regression lines for the pre- and post-change groups will give the better estimate of the serial dependency between points.

<u>Program Description</u>

The computer program TIMSX is designed to perform the following statistical tests on data of the interrupted time series form:

1. Mood test
2. Walker-Lev covariance tests
3. "double extrapolation"

The tests desired are indicated on card input to the program (see card preparation).

The program also calculates autocorrelation coefficients for lags 1 through 4. The autocorrelations are also given for the departures from the

regression line based on the total series and from the separate regression lines for the pre- and post-change values.

A data plot of the time series may also be obtained. In the data plot, the pre-change and post-change observation values are indicated by separate plotting characters. Initial and terminal points for regression lines based on the pre-change and post-change values and on the total series are indicated on the plot, if desired.

In addition to the t or F values of each statistical test of significance, the information outlined below may also be obtained. This option must be indicated on card input.

(a) Mood Test

*standard error for t test
*estimated y-value for the first post-change point
*obtained y-value for the first post-change point
*slope and intercept for the pre-change points
*variance of the obtained pre-change points from the regression estimated values

(b) Walker-Lev Tests

Test 1
*numerator and denominator sum of squares for F
*regression estimates (slope and intercept) for pre-change values
*estimated y-value at experimental change (that is, midway between last pre-change and first post-change points) based upon pre-change regression estimates
*regression estimates for post-change values
*estimated y-value at experimental change based upon post-change regression estimates
*common within groups regression estimates for the pre-change values
*estimated y-value at experimental change based upon the above regression estimates
*common within groups regression estimates for post-change values
*estimated y-value at experimental change based upon the above regression estimates

Test 2

*numerator and denominator sum of squares for F

Test 3

*numerator and denominator sum of squares for F
*regression estimates (slope and intercept) for the total series
*estimated y-value at experimental change based upon the above regression estimates

(c) Double Extrapolation Technique for Mood Test

*standard error for t test
*regression estimates for pre-change values
*variance of the obtained pre-change points from the values predicted on basis of the above regression estimates
*estimated y-value at experimental change based upon pre-change regression estimates
*regression estimates for the post-change values
*variance of the obtained post-change points from the values predicted on the basis of the above regression estimates
*estimated y-value at experimental change based upon post-change regression estimates

Program Limitations

The total number of occasion values must not be greater than 400. This is an arbitrary limit; the program could be modified to handle more than 400 points.

The data plot will not indicate more than 25 pre-change data points and/or 25 post-change data points.

Running Time Estimation

The following running times are reported to illustrate the relationship between size of sample and length of computer run.

Total N	Running Time*	Pages of Output
29	.09 min.	2
200	.10 min.	3

*Three Tests of Significance and Data Plot.

Card Preparation

The format and meaning of cards that are input to this program are described below.

a. Title Card

Col. 1-80 Identifying alphanumeric information. This information will appear as a heading on the print-out and on the data plot.

b. Occasion Card

Col. 1-3 Total number of occasions in the time series. The maximum number of occasions allowed is 400. The number of occasions in the pre- and post-change groups must be specified in Col. 4-9 below. The program assumes the y or occasion values occur at equalintervals in time.

Col. 4-6 Number of occasions in the pre-change group.

Col. 7-9 Number of occasions in the post-change group.

c. Test Specification Card

Col. 1 1 if calculations of serial correlation coefficients is desired.
0 (or blank) if you do not wish to have these calculations performed.

Col. 2 1 if Mood test is desired.
0 (or blank) if this statistical test is not desired.

Col. 3 1 if the Walker-Lev covariance tests are desired.
0 (or blank) if these tests are not desired.

Col. 4 1 if the "double extrapolation" technique for a double Mood test is desired.
0 (or blank) if this test is not desired.

Col. 5 1 if you wish to have the additional information specified on pages 13-14 printed out for each test of significance specified above.
0 (or blank) if you wish to have only the t or F values and the df for each test of significance. The additional information is not printed out.

Col. 6 1 if a data plot of input data points is desired.
2 if you wish terminal points for the regression lines based on pre-change and post-change values and on the total series to be indicated on the plot.
0 (or blank) if the data plot is not desired.

d. Variable Format Card

Col. 1-80 This card precedes the first data card. The format specification starts in the first card column and must be completed in 80 columns. The statement is enclosed by parentheses. The word FORMAT is not used, otherwise the format specification is as described in the FORTRAN manual. Only F and X conversion is allowed.

e. Data Cards

The data cards follow the Variable Format Card. The data arrangement on each card must be that given by the format specification on the Variable Format Card. However, it may sometimes occur that your last data card has less values than the preceding cards. This one exception is allowed.

Order of Cards

More than one problem can be processed consecutively. The following example illustrates the order of cards.

Title Card
Occasion Card
Test Specification Card
Variable Format Card
Data Cards

Title Card
Occasion Card
. . .
etc.

```
C       THE INTERRUPTED TIME SERIES AS QUASI-EXPERIMENT
C       THREE TESTS OF SIGNIFICANCE
C       PROGRAMMED BY JOYCE SWEEN,NORTHWESTERN UNIVERSITY
C
C       PLEASE SEE PROGRAM WRITEUP FOR SPECIFICATION CARDS REQUIRED
C       AS INPUT TO THIS PROGRAM AND FOR DESCRIPTION OF INPUT CARD ORDER.
C
      DIMENSION ITITLE(10),IFMDAT(10),T(400),Y(400),P(400),ZTOT(400),
     1ZPART(400)
      TYPE INTEGER MCD1,MCD2,BCDP1,BCDP2,BCDPT
C
C       READ SPECIFICATION AND DATA CARDS
C
  100 READ(60,10) ITITLE
      IF(EOF,60)999,110
  110 READ(60,11)NTOT,NPRE,NPOST
      IF(NTOT.GT.400) GO TO 91
      IF((NPRE+NPOST).NE.NTOT) GO TO 91
      READ(60,12)LAGCO,MCOD,LEV,MCOD2,MORE,NPLOT
      READ(60,10)IFMDAT
      READ(60,IFMDAT) (Y(I),I=1,NTOT)
      DO 402 I=1,NTOT
  402 T(I)=I
      NPRE1=NPRE+1 $PRE=NPRE $POST=NPOST $ TOT=NTOT
      IF((MCOD+LEV+MCOD2).EQ.0) GO TO 473
      WRITE(6,29)
      WRITE(6,30) ITITLE
      WRITE OUTPUT TAPE 6,130
      WRITE OUTPUT TAPE 6,120,(Y(I),I=1,NPRE)
      WRITE OUTPUT TAPE 6,131
      WRITE OUTPUT TAPE 6,120,(Y(I),I=NPRE1,NTOT)
      IF(LAGCO.NE.0)1100,409
C
C       CALCULATE AUTOCORRELATION COEFFICIENTS,IF OPTED
C
 1100 CALL LINE(1,NPRE,NPRE,T,Y,ALPHA1,BETA1)
      DO 1101 I=1,NPRE
 1101 P(I)=Y(I)-ALPHA1-(BETA1*T(I))
      CALL LINE(NPRE1,NTOT,NPOST,T,Y,ALPHA2,BETA2)
      DO 1102 I=NPRE1,NTOT
 1102 P(I)=Y(I)-ALPHA2-(BETA2*T(I))
      CALL SERIAL(NTOT,4,P,RSEP4)
      CALL SERIAL(NTOT,3,P,RSEP3)
      CALL SERIAL(NTOT,2,P,RSEP2)
      CALL SERIAL(NTOT,1,P,RSEP1)
      CALL LINE(1,NTOT,NTOT,T,Y,ALPHAT,BETAT)
      DO 1111 I=1,NTOT
 1111 P(I)=Y(I)-ALPHAT-(BETAT*T(I))
      CALL SERIAL(NTOT,4,P,RTOT4)
      CALL SERIAL(NTOT,3,P,RTOT3)
      CALL SERIAL(NTOT,2,P,RTOT2)
      CALL SERIAL(NTOT,1,P,RTOT1)
      CALL SERIAL(NTOT,4,Y,RSNR4)
      CALL SERIAL(NTOT,3,Y,RSNR3)
      CALL SERIAL(NTOT,2,Y,RSNR2)
      CALL SERIAL(NTOT,1,Y,RSNR1)
```

```
      WRITE(6,54)
      WRITE OUTPUT TAPE 6,46
      WRITE(6,55)RTOT1,RTOT2,RTOT3,RTOT4
      WRITE OUTPUT TAPE 6,47
      WRITE OUTPUT TAPE 6,55,RSEP1,RSEP2,RSEP3,RSEP4
      WRITE OUTPUT TAPE 6,45
      WRITE OUTPUT TAPE 6,55,RSNR1,RSNR2,RSNR3,RSNR4
  409 IF(MCOD.NE.0)700,418
C
C       MCOD TEST CALCULATIONS, IF OPTED
C
  700 CALL LINE(1,NPRE,NPRE,T,Y,ALPHA,BETA)
      DIFS=0
      DO 718 I=1,NPRE
      DIFI=Y(I)-ALPHA-(BETA*T(I))
00718 DIFS=DIFS +(DIFI*DIFI)
      YO=ALPHA +(BETA*(PRE+1.0))
      DIFY=ABSF(Y(NPRE+1)-YO)
      TBAR=SUMT/PRE
      YBAR=SUMY/PRE
      TCR=(PRE+1.0)-TBAR
      TCR2=TCR * TCR
      TIR2=0
      DO 728 I=1,NPRE
      TIRI=T(I)-TBAR
00728 TIR2=TIR2 +(TIRI*TIRI)
      CON1= ABSF(((PRE+1.0)/PRE)+(TCR2/TIR2))
      CON1=SORTF(CON1)
      CON2= ABSF(DIFS/(PRE-2.0))
      CON2=SORTF(CON2)
      SE=CON1*CON2
      TMCOD=DIFY/SE
      MDF=NPRE-2
      VARM=DIFS/PRE
      IF(MORE.EQ.1)413,417
00413 WRITE OUTPUT TAPE 6,56,TMCOD,MDF
      WRITE OUTPUT TAPE 6,57,SE,YO,Y(NPRE1)
      WRITE OUTPUT TAPE 6,58,BETA,ALPHA,VARM
      GO TO 418
00417 WRITE OUTPUT TAPE 6,56,TMCOD,MDF
  418 IF(LEV.NE.0)900,429
C
C       WALKER-LEV CALCULATIONS,IF OPTED
C
  900 SUMT1=0
      SUMY1=0
      SUMTY1=0
      SUMTT1=0
      SUMYY1=0
      DO 910 I=1,NPRE
      SUMT1=SUMT1+T(I)
      SUMY1=SUMY1+Y(I)
      SUMTY1=SUMTY1+(T(I)*Y(I))
      SUMTT1=SUMTT1+(T(I)*T(I))
00910 SUMYY1=SUMYY1+(Y(I)*Y(I))
      SUMT2=0
      SUMY2=0
```

```
      SUMTT2=0
      SUMYY2=0
      DO 921 I=NPRE1,NTOT
      SUMT2=SUMT2+T(I)
      SUMY2=SUMY2+Y(I)
      SUMTY2=SUMTY2 +(T(I)*Y(I))
      SUMTT2=SUMTT2 +(T(I)*T(I))
00921 SUMYY2=SUMYY2+(Y(I)*Y(I))
      CTY1=SUMTY1-((SUMT1*SUMY1)/PRE)
      CTY2=SUMTY2-((SUMT2*SUMY2)/POST)
      CTT1=SUMTT1-((SUMT1*SUMT1)/PRE)
      CTT2=SUMTT2-((SUMT2*SUMT2)/POST)
      CYY1=SUMYY1-((SUMY1*SUMY1)/PRE)
      CYY2=SUMYY2-((SUMY2*SUMY2)/POST)
      CTYW=CTY1+CTY2
      CTTW=CTT1+CTT2
      CYYW=CYY1+CYY2
      CTYT=(SUMTY1+SUMTY2)-(((SUMT1+SUMT2)*(SUMY1+SUMY2))/TOT)
      CTTT=(SUMTT1+SUMTT2)-(((SUMT1+SUMT2)*(SUMT1+SUMT2))/TOT)
      CYYT=(SUMYY1+SUMYY2)-(((SUMY1+SUMY2)*(SUMY1+SUMY2))/TOT)
      CYYB=CYYT-CYYW
      C2TYW=CTYW*CTYW
      C2TYT=CTYT*CTYT
      C2TY1=CTY1*CTY1
      C2TY2=CTY2*CTY2
      S1=((C2TY1/CTT1)+(C2TY2/CTT2))-(C2TYW/CTTW)
      S2=CYYW-((C2TY1/CTT1)+(C2TY2/CTT2))
      PLEV1=(S1/S2)*(TOT-4.0)
      L1DF=NTOT-4
      SSD=(CTTW*CYYW)-C2TYW
      PLEV2=(C2TYW/SSD)*(TOT-4.0)
      L2DF=L1DF
      SB=CYYB+(C2TYW/CTTW)-(C2TYT/CTTT)
      SW=S1+S2
      PLEV3=(SB/SW)*(TOT-3.0)
      L3DF=NTOT-3
      IF(MORE.NE.0)954,423
00954 BS1=CTY1/CTT1
      Y1BAR=SUMY1/PRE
      T1BAR=SUMT1/PRE
      AS1=Y1BAR-(BS1*T1BAR)
      BS2=CTY2/CTT2
      Y2BAR=SUMY2/POST
      T2BAR=SUMT2/POST
      AS2=Y2BAR-(BS2*T2BAR)
      BW=CTYW/CTTW
      AW1=Y1BAR-(BW*T1BAR)
      AW2=Y2BAR-(BW*T2BAR)
      BT=CTYT/CTTT
      AT=((SUMY1+SUMY2)/TOT)-(BT*((SUMT1+SUMT2)/TOT))
      TX=PRE+0.5
      YIX1=(BS1*TX)+AS1
      YIX2=(BS2*TX)+AS2
      YIXC1=(BW*TX)+AW1
      YIXC2=(BW*TX)+AW2
      YIXT=(BT*TX)+AT
```

```
00422 WRITE OUTPUT TAPE 6,54
      WRITE OUTPUT TAPE 6,60,FLEV1,L1DF
      WRITE OUTPUT TAPE 6,61,S1,S2
      WRITE OUTPUT TAPE 6,62
      WRITE OUTPUT TAPE 6,63,BS1,AS1
      WRITE OUTPUT TAPE 6,78,Y1X1
      WRITE OUTPUT TAPE 6,64,BS2,AS2
      WRITE OUTPUT TAPE 6,78,Y1X2
      WRITE OUTPUT TAPE 6,65
      WRITE OUTPUT TAPE 6,63,Bw,Aw1
      WRITE OUTPUT TAPE 6,78,Y1XC1
      WRITE OUTPUT TAPE 6,64,Bw,Aw2
      WRITE OUTPUT TAPE 6,78,Y1XC2
      WRITE OUTPUT TAPE 6,66,FLEV2,L2DF
      WRITE OUTPUT TAPE 6,136,C2TYw,SSD
      WRITE OUTPUT TAPE 6,67,FLEV3,L3DF
      WRITE OUTPUT TAPE 6,61,SB,SW
      WRITE OUTPUT TAPE 6,68
      WRITE OUTPUT TAPE 6,69,BT,AT
      WRITE OUTPUT TAPE 6,78,Y1XT
      GO TO 429
  423 WRITE(6,59)
      WRITE OUTPUT TAPE 6,60,FLEV1,L1DF
      WRITE OUTPUT TAPE 6,66,FLEV2,L2DF
      WRITE OUTPUT TAPE 6,67,FLEV3,L3DF
  429 IF(MODD2.NE.0)1200,473
C
C       DOUBLE MODD CALCULATIONS, IF OPTED
C
 1200 CALL LINE(1,NPRE,NPRE,T,Y,ALPHA1,BETA1)
      Y01=ALPHA1 + (BETA1 * (PRE + 0.5))
      CALL LINE(NPRE1,NTOT,NPOST,T,Y,ALPHA2,BETA2)
      Y02 =ALPHA2 +  (BETA2*(PRE+0.5))
      SUMY=0$SUMT=0$SUMTT=0$SUMYY=0$SUMTY=0
      DO 1210 I=1,NPRE
      SUMY =SUMY  + Y(I)
      SUMT =SUMT  + T(I)
      SUMTT =SUMTT  + (T(I)*T(I))
      SUMYY=SUMYY+(Y(I)*Y(I))
 1210 SUMTY=SUMTY+(T(I)*Y(I))
      CYY1=SUMYY - ((SUMY*SUMY)/PRE)
      CTT1=SUMTT - ((SUMT*SUMT)/PRE)
      CTY1=SUMTY - ((SUMT*SUMY)/PRE)
      THAR1=SUMT/PRE
      SUMY=0$SUMT=0$SUMTT=0$SUMYY=0$SUMTY=0
      DO 1234 I=NPRE1,NTOT
      SUMY= SUMY + Y(I)
      SUMT= SUMT + T(I)
      SUMTT=SUMTT + (T(I)* T(I))
      SUMYY=SUMYY + (Y(I)* Y(I))
 1234 SUMTY=SUMTY + (T(I)* Y(I))
      CYY2=SUMYY-((SUMY*SUMY)/POST)
      CTT2=SUMTT-((SUMT*SUMT)/POST)
      CTY2=SUMTY-((SUMT*SUMY)/POST)
      THAR2=SUMT/POST
      DIFY= ABSF(Y01-Y02)
      C2TY1=CTY1*CTY1
```

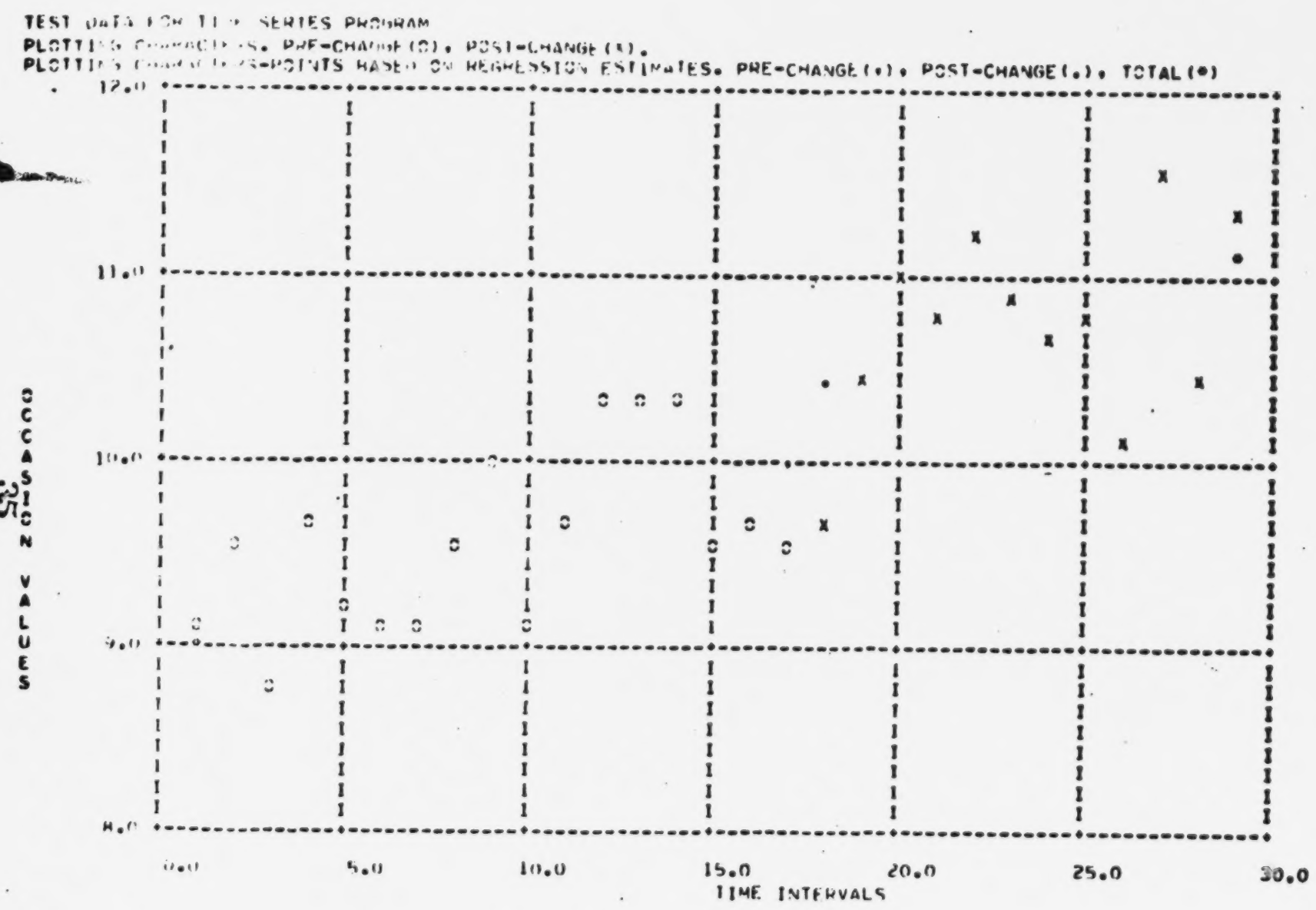
```
      U1=CYY1 -(C2TY1/CTT1)
      V1=(((PRE+ 0.5)-TBAR1)*((PRE+0.5)-TBAR1))/CTT1
      C2TY2=CTY2 *CTY2
      U2= CYY2 -(C2TY2/CTT2)
      V2=(((PRE+0.5) -TBAR2)*((PRE+0.5)-TBAR2))/CTT2
      TOP=(U1 + U2)*((TOT/(PRE*POST))+ V1 +V2)
      SE=  ABSF(TOP/(PRE + POST-4.0))
      SE=SQRTF(SE)
      TMCOD2=DIFY/SE
      M2DF=NTOT-4
      IF(MORE.NE.0)1257,433
 1257 DIFSQ =0
      DO 1260 I=1,NPRE
      DIFI  =Y(I)-ALPHA1 -(BETA1 *T(I))
 1260 DIFSQ=DIFSQ+(DIFI*DIFI)
      VAR1=DIFSQ/PRE
      DIFSQ=0
      DO 1265 I=NPRE1 ,NTOT
      DIFI  = Y(I)-ALPHA2-(BETA2 * T(I))
 1265 DIFSQ=DIFSQ+(DIFI*DIFI)
      VAR2=DIFSQ/POST
      WRITE OUTPUT TAPE 6,73,TMCOD2,M2DF
      WRITE OUTPUT TAPE 6,74,SE
      WRITE OUTPUT TAPE 6,75,BETA1,ALPHA1
      WRITE OUTPUT TAPE 6,76,VAR1,Y01
      WRITE OUTPUT TAPE 6,77,BETA2,ALPHA2
      WRITE OUTPUT TAPE 6,76,VAR2,Y02
      GO TO 473
  433 WRITE OUTPUT TAPE 6,73,TMCOD2,M2DF
  473 IF(NPLOT.NE.0)476,100
  476 WRITE(6,29)
      WRITE(6,30) ITITLE
C
C       DATA PLOT, IF OPTED
C
 2500 BCD1=1HC
      BCD2=1HX
      IF(NPLOT-1)2532,2531
 2531 IF(NTOT-50)2501,2501,2502
 2501 CALL STPLT2(1,T(1),Y(1),NTOT)
      CALL PLOT3(BCD1,T(1),Y(1),NPRE)
      CALL PLOT3(BCD2,T(NPRE1),Y(NPRE1),NPOST)
      GO TO 2525
 2502 IF(NPRE-25) 2511,2511,2512
 2511 CALL STPLT2(1,T(1),Y(1),50)
      CALL PLOT3(BCD1,T(1),Y(1),NPRE)
      NUM2= 50-NPRE
      CALL PLOT3(BCD2,T(NPRE1),Y(NPRE1),NUM2)
      GO TO 2525
 2512 IF(NPOST-25) 2513,2513,2514
 2513 NUM1=50-NPOST
      I1=1+(NTOT-50)
      CALL STPLT2(1,T(I1),Y(I1),50)
      CALL PLOT3(BCD1,T(I1),Y(I1),NUM1)
      CALL PLOT3(BCD2,T(NPRE1),Y(NPRE1),NPOST)
      GO TO 2525
 2514 I1=1+(NPRE-25)
```

```
      CALL SIPLT2(1,T(II),Y(II),50)
      CALL PLOT3(BCD1,T(II),Y(II),25)
      CALL PLOT3(BCD2,T(NPRE1),Y(NPRE1),25)
      GO TO 2525
 2525 WRITE OUTPUT TAPE 6,147
      CALL FPLOT4(30,30H                    OCCASION VALUES)
      WRITE OUTPUT TAPE 6,149
      GO TO 100
 2532 CALL LINE(1,NTOT,NTOT,T,Y,BTT,SLOPET)
      DO 2551 I=1,NTOT
 2551 ZTOT(I)=(SLOPET * T(I))+ BTT
      CALL LINE(1,NPRE,NPRE,T,Y,B1,SLOPE1)
      DO 2553 I=1,NPRE
 2553 ZPART(I)=(SLOPE1 * T(I))+ B1
      CALL LINE(NPRE1,NTOT,NPOST,T,Y,B2,SLOPE2)
      DO 2555 I=NPRE1,NTOT
 2555 ZPART(I)=(SLOPE2 * T(I))+B2
      BCOP1=1H
      BCOP2=1H
      BCOPT=1H
      IF(NTOT-50)2561,2561,2562
 2561 NUM1=NPRE
      NUM2=NPOST
      NUMT=NTOT
      IB=1
      IN=NTOT
      GO TO 2585
 2562 IF(NPRE-25)2571,2571,2572
 2571 NUM1=NPRE
      NUM2=50-NPRE
      NUMT=50
      IB=1
      IN=50
      GO TO 2585
 2572 IF(NPOST-25)2573,2573,2574
 2573 NUM1=50-NPOST
      NUM2=NPOST
      NUMT=50
      IB=1+(NTOT-50)
      IN=IB+49
      GO TO 2585
 2574 NUM1=25
      NUM2=25
      NUMT=50
      IB=1+(NPRE-25)
      IN=IB+49
      GO TO 2585
 2585 CALL SIPLT2(I,T(IB),Y(IB),NUMT)
      CALL PLOT3(BCOP1,T(IB),ZPART(IB),1)
      CALL PLOT3(BCOP1,T(NPRE),ZPART(NPRE),1)
      CALL PLOT3(BCOP2,T(NPRE1),ZPART(NPRE1),1)
      CALL PLOT3(BCOP2,T(IN),ZPART(IN),1)
      CALL PLOT3(BCOPT,T(IB),ZTOT(IB),1)
      CALL PLOT3(BCOPT,T(IN),ZTOT(IN),1)
      DO 2586 I=IB,NPRE
 2586 CALL PLOT3(BCD1,T(I),Y(I),NUM1)
      DO 2587 I=NPRE1,IN
```

```
 2587 CALL PLOT3(RCD2,T(I),Y(I),NUM2)
      WRITE OUTPUT TAPE6,147
      WRITE OUTPUT TAPE 6,148
      CALL FPLOT4(30,30H                    OCCASION VALUES)
      WRITE OUTPUT TAPE 6,149
      GO TO 100
   91 WRITE(6,991)
  999 STOP
C
C      FORMAT STATEMENTS
C
   10 FORMAT(10A8)
   11 FORMAT(3I3)
   12 FORMAT(6I1)
   29 FORMAT(1H1)
   30 FORMAT(1H ,10A8)
  120 FORMAT(10F10.2)
  130 FORMAT(33HOPRE-EXPERIMENTAL OCCASION VALUES)
  131 FORMAT(34H POST-EXPERIMENTAL OCCASION VALUES)
   54 FORMAT(32HOSERIAL CORRELATION COEFFICIENTS)
   55 FORMAT( 6H R(1)=F6.2,8H   R(2)=F6.2,8H   R(3)=F6.2,8H   R(4)=F6.2)
   45 FORMAT(1H ,5X,31HSLOPE AND INTERCEPT NOT REMOVED)
   46 FORMAT(1H ,5X,55HSLOPE AND INTERCEPT REMOVED (TOTAL REGRESSION EST
     1IMATE))
   47 FORMAT(1H ,5X,72HSLOPE AND INTERCEPT REMOVED (SEPARATE PRE AND POS
     1T REGRESSION ESTIMATES))
   56 FORMAT(23HOMOOD TEST            T=F7.2,7H    DF=I3)
   57 FORMAT(19H    STANDARD ERROR=F12.2,13H  Y ESTIMATE=F12.2,4H  Y=F12
     1.2)
   58 FORMAT(10H    SLOPE=F12.3,13H   INTERCEPT=F12.3,12H   VARIANCE=F15
     1.2)
   59 FORMAT(17HOWALKER-LEV TESTS)
   60 FORMAT(23H    TEST 1             F=F7.2,9H    DF=1,I3)
   61 FORMAT(19H      NUMERATOR SS=F15.2,19H    DENOMINATOR SS=F15.2)
   62 FORMAT(41H      SEPARATE GROUP REGRESSION ESTIMATES)
   63 FORMAT(30H         PRE-X GROUP    SLOPE=F12.3,13H   INTERCEPT=F12.
     13)
   64 FORMAT(30H         POST-X GROUP   SLOPE=F12.3,13H   INTERCEPT=F12.
     13)
   65 FORMAT(47H      COMMON WITHIN GROUPS REGRESSION ESTIMATES)
   66 FORMAT(23H    TEST 2             F=F7.2,9H    DF=1,I3)
   67 FORMAT(23H    TEST 3             F=F7.2,9H    DF=1,I3)
   68 FORMAT(41H      COMBINED GROUPS REGRESSION ESTIMATE)
   69 FORMAT(30H         TOTAL GROUP    SLOPE=F12.3,13H   INTERCEPT=F12.
     13)
   73 FORMAT(23HODOUBLE MOOD TEST     T=F7.2,7H    DF=I3)
   74 FORMAT(19H    STANDARD ERROR=F12.2)
   75 FORMAT(25H    PRE-X GROUP    SLOPE=F12.3, 13H   INTERCEPT=F12.3)
   76 FORMAT(22H              VARIANCE=F15.2,21H   ESTIMATED VALUE Y=F12.
     12)
   77 FORMAT(25H    POST-X GROUP   SLOPE=F12.3,13H   INTERCEPT=F12.3)
   78 FORMAT(48H                                ESTIMATED Y VALUE AT X=F12.2)
  136 FORMAT(19H      NUMERATOR SS=F15.2,19H    DENOMINATOR SS=F15.2)
  147 FORMAT(52H PLOTTING CHARACTERS, PRE-CHANGE(C), POST-CHANGE(X),)
  148 FORMAT(98H PLOTTING CHARACTERS-POINTS BASED ON REGRESSION ESTIMATE
     1S, PRE-CHANGE(,), POST-CHANGE(.), TOTAL(*))
  149 FORMAT(72H
```

```
     1  11.4F INTERVALS)
991 FORMAT(1H ,*ERROR IN SPECIFICATION CARD. PROGRAM TERMINATED*)
    END)
```

```
      SUBROUTINE SERIAL(NT,N,V,RU)
      DIMENSION V(400)
      SUMX=0
      SUMX=0
      SUMY=0
      SUMXX=0
      SUMYY=0
      NN=NT-N
      DO 6002 I=1,NN
      IN=I+N
      SUMXY=SUMXY+(V(I)*V(IN))
      SUMX=SUMX+V(I)
      SUMY=SUMY+V(IN)
      SUMXX=SUMXX+(V(I)*V(I))
6002  SUMYY=SUMYY+(V(IN)*V(IN))
      TOT=NN
      TOP=(TOT * SUMXY)-(SUMX * SUMY)
      DENOM1= ABSF((TOT*SUMXX)-(SUMX * SUMX))
      DENOM1=SQRTF(DENOM1)
      DENOM2= ABSF((TOT *SUMYY)-(SUMY * SUMY))
      DENOM2=SQRTF(DENOM2)
      RU=TOP/(DENOM1*DENOM2)
      RETURN
      END
```


TEST DATA FOR TIME SERIES PROGRAM
PLOTTING CHARACTERS. PRE-CHANGE (O). POST-CHANGE (X).
PLOTTING CHARACTERS-POINTS BASED ON REGRESSION ESTIMATES. PRE-CHANGE (•). POST-CHANGE (•). TOTAL (•)
12.0
11.0
10.0
9.0
8.0
OCCASION VALUES
0.0
5.0
10.0
15.0
20.0
25.0
30.0
TIME INTERVALS

```
      SUBROUTINE LINE(N1,N2,NT,T,Y,ALPHA,BETA)
      DIMENSION T(400),Y(400)
      SUMY=0
      SUMT=0
      SUMTT=0
      SUMTY=0
      DO 6001 I=N1,N2
      SUMTY=SUMTY+(T(I)*Y(I))
      SUMT=SUMT + T(I)
      SUMY=SUMY + Y(I)
 6001 SUMTT= SUMTT + (T(I)*T(I))
      TOT=NT
      TOP=(TOT*SUMTY)-(SUMT*SUMY)
      DENOM=(TOT*SUMTT)-(SUMT * SUMT)
      BETA=TOP/DENOM
      TOP=(SUMTT * SUMY)-(SUMT * SUMTY)
      ALPHA=TOP/DENOM
      RETURN
      END
```

```
TEST DATA FOR TIME SERIES PROGRAM

PRE-EXPERIMENTAL OCCASION VALUES
     9.10      9.53      8.73      9.62      9.20      9.10      9.10      9.53     10.00      9.13
     9.62     10.31     10.30     10.38      9.51      9.69      9.52
POST-EXPERIMENTAL OCCASION VALUES
     9.72     10.41     10.98     10.90     11.23     10.90     10.70     10.80     10.13     11.60
    10.43     11.42

SERIAL CORRELATION COEFFICIENTS
     SLOPE AND INTERCEPT REMOVED (TOTAL REGRESSION ESTIMATE)
R(1)= 0.02   R(2)= 0.14   R(3)= -0.24   R(4)= -0.40
     SLOPE AND INTERCEPT REMOVED (SEPARATE PRE AND POST REGRESSION ESTIMATES)
R(1)= -0.04   R(2)= 0.13   R(3)= -0.24   R(4)= -0.39
     SLOPE AND INTERCEPT NOT REMOVED
R(1)= 0.67   R(2)= 0.72   R(3)= 0.54   R(4)= 0.51

MOOD TEST              T=   0.71    DF= 15
   STANDARD ERROR=        0.45  Y ESTIMATE=       10.04  Y=        9.72
   SLOPE=      0.054   INTERCEPT=       9.077   VARIANCE=         0.14

WALKER-LEV TESTS
   TEST 1              F=   0.03    DF=1, 25
     NUMERATOR SS=          0.01    DENOMINATOR SS=          4.96
     SEPARATE GROUP REGRESSION ESTIMATES
        PRE-X GROUP    SLOPE=       0.054   INTERCEPT=       9.077
                       ESTIMATED Y VALUE AT X=       10.01
        POST-X GROUP   SLOPE=       0.061   INTERCEPT=       9.324
                       ESTIMATED Y VALUE AT X=       10.39
     COMMON SLOPE GROUPS REGRESSION ESTIMATES
        PRE-X GROUP    SLOPE=       0.055   INTERCEPT=       9.061
                       ESTIMATED Y VALUE AT X=       10.03
        POST-X GROUP   SLOPE=       0.055   INTERCEPT=       9.449
                       ESTIMATED Y VALUE AT X=       10.42
   TEST 2              F=   8.52    DF=1, 25
     NUMERATOR SS=        932.39    DENOMINATOR SS=       2737.16
   TEST 3              F=   1.50    DF=1, 26
     NUMERATOR SS=          0.29    DENOMINATOR SS=          4.97
     COMBINED GROUPS REGRESSION ESTIMATE
        TOTAL GROUP    SLOPE=       0.075   INTERCEPT=       8.929
                       ESTIMATED Y VALUE AT X=       10.24

DOUBLE MOOD TEST     T=   1.10    DF= 25
   STANDARD ERROR=        0.34
   PRE-X GROUP    SLOPE=       0.054   INTERCEPT=       9.077
          VARIANCE=          0.14   ESTIMATED VALUE Y=       10.01
   POST-X GROUP   SLOPE=       0.061   INTERCEPT=       9.324
          VARIANCE=          0.21   ESTIMATED VALUE Y=       10.39
```

References

Campbell, D. T. From description to experimentation: interpreting trends as quasi-experiments. In C. W. Harris (Ed.), Problems in measuring change. Madison, Wis.: Univer. Wisconsin Press, 1963, pp. 212-242

Campbell, D. T., & Stanley, J. C. Experimental and quasi-experimental designs for research on teaching. In N. L. Gage (Ed.), Handbook of Research on teaching. Chicago: Rand McNally, 1963, pp. 171-246.

Grenander, U., & Rosenblat, M. Statistical analysis of stationary time series. New York: Wiley, 1957.

Holtzman, Wayne, H. Statistical models for the study of change in the single case. In C. W. Harris (Ed.), Problems in measuring change. Madison, Wis.: Univer. Wisconsin Press, 1963, pp. 199-211.

Mood, S. M. Introduction to the theory of statistics. New York: McGraw-Hill, 1950

Sween, J., and Campbell, D. T. A study of the effect of proximally autocorrelated error on tests of significance for the interrupted time series quasi-experimental design. Mimeographed research report, Department of Psychology, Northwestern University, 1965.

Walker, H. M., & Lev, J. Statistical Inference. New York: Holt, 1953.

Appendix I

Interpretation of Data Plot with Missing Regression Points

If a 2 is placed in Col. 6 of the Test Specification Card, initial and terminal points for the regression lines based on pre-change and post-change values and on the total series are indicated on the data plot. The printing characters for the regression estimates are as follows:

, pre-change regression estimates
. post-change regression estimates
* total series regression estimates

It may sometimes occur that some of these points are missing from the plot. This is because the RUMPLOT subroutine prints only one point at a particular co-ordinate location. If more than one point falls on the same location, one point is printed and the others are surpressed. It is usually possible to determine the location of the missing point directly, although in some instances additional information regarding slopes and intercepts is required. The outline below will facilitate the location of missing points.

(1) Missing total regression estimates (*)

The initial point for the total series regression line is located at time t_1. If there are more than 25 pre-change points it is located at time $t_{N_1}-24$. If the initial point for the total regression line is not plotted it is located at the first plotted pre-change occasion value (0).

The terminal point for the total series regression line is located at time t_{N_2}. If there are more than 25 post-change points it is located at time t_{N_1+25}. If the terminal point for the total regression line is not plotted it is located at the last plotted post-change occasion value (X).

(2) Missing pre-change regression estimates (,)

The initial point for the pre-change regression line is located at time t_1.

If there are more than 25 pre-change points, it is located at time t_{N_1-24}. If the initial pre-change regression estimate is not plotted and if the initial total regression estimate is not plotted, the initial pre-change regression estimate is located at the first plotted occasion value (0). However, if the initial total regression estimate is plotted, additional information is needed to locate the missing point (it may be at * or 0). Namely, the location of the missing point must be determined from the slope and intercept of the regression line.

The terminal point for the pre-change regression line is located at time t_{N_1}. If this point is missing it is located at the last pre-change occasion value (0).

(3) Missing post-change regression estimates (.)

The initial point for the post-change regression line is located at time t_{N_1+1}. If this point is missing, it is located at the first post-change occasion value (X).

The terminal point for the post-change regression line is located at time t_{N_2}. If there are more than 25 post-change points, the terminal point is located at time t_{N_1+25}. If the terminal point for the post-change regression line is not plotted and if the terminal point for the total regression line is not plotted, the missing post-change regression estimate is located at the last plotted occasion value (X). However, if the total terminal regression estimate is plotted, additional information is needed to locate the missing point (it may be at X or *). Namely, the correct location for the missing point must be determined from the slope and intercept of the regression line.

Appendix II

Program Modifications for Fortran II and IV

Program TIMEX is written in CDC 3400 FORTRAN for use with card input and printed output. Modifications for FORTRAN II and IV for the IBM 709/7090 are indicated by reference to statement number. When a statement has no number, modifications are indicated by the number of statements "plus" or "minus" the nearest statement number which are needed to locate the modification.

Statement Number	Modification
100 minus 2	DIMENSION statement should read (ITITLE(12), IFMDAT(12) Also change Card Preparation instructions to indicate that Title Card and Variable Format Card should be punched only in Col. 1-72.
100 minus 1	TYPE statement not required.
1100 minus 1	Change to Arithmetic IF statement.
700 minus 1	Change to Arithmetic IF statement.
418	Change to Arithmetic IF statement.
429	Change to Arithmetic IF statement.
1200 plus 4	$ notation not allowed. Change to separate statements.
1210 plus 5	$ notation not allowed. Change to separate statements.
1257 minus 1	Change to Arithmetic IF statement.
473	Change to Arithmetic IF statement.
991	* notation not allowed. Change to H-specification.

In addition, check all READ and WRITE statements for compatibility with FORTRAN II and IV.